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THE EFFECTS OF FOREST FIRES ON THE VEGETATION OF INTERIOR ALASKA

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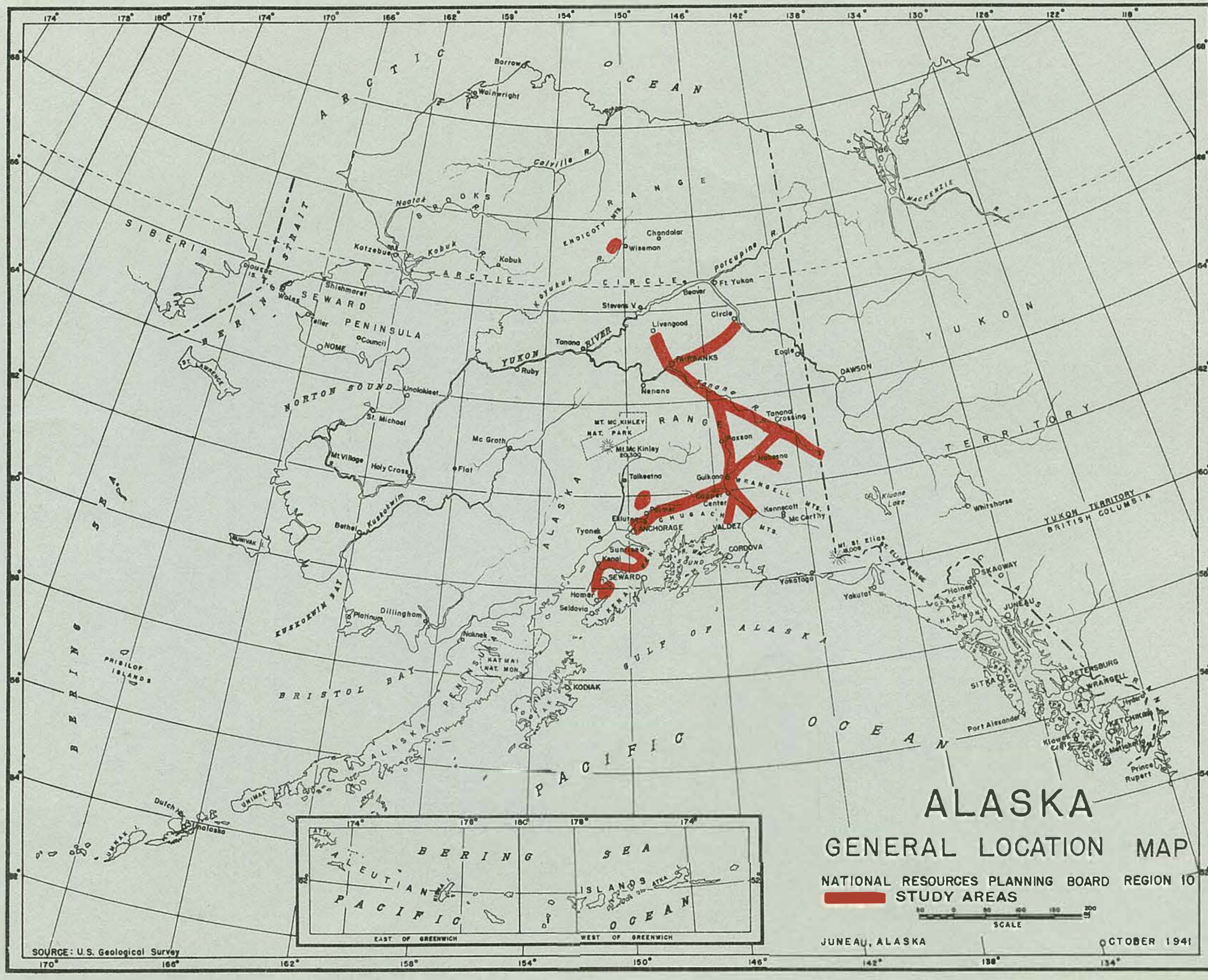

ALASKA
GENERAL LOCATION MAP
NATIONAL RESOURCES PLANNING BOARD REGION 10
STUDY AREAS
SCALE
JUNEAU, ALASKA
OCTOBER 1941
SOURCE: U.S. Geological Survey
ARCTIC OCEAN
PACIFIC OCEAN
BERING SEA
GULF OF ALASKA
BRISTOL BAY
NORTON SOUND
BROOKS RANGE
ALASKA RANGE
YUKON TERRITORY
BRITISH COLUMBIA
SIBERIA
SEWARD PENINSULA
ALEUTIAN ISLANDS
EAST OF GREENWICH
WEST OF GREENWICH
Barrow
Wainwright
Kotzebue
Nome
Fairbanks
Anchorage
Valdez
Cordova
Seward
Juneau
Skagway
Sitka
Ketchikan
Dawson
Whitehorse
Kodiak

FOREWORD

The future economic development of Alaska's vast Interior is endangered by uncontrolled fires ranging over vast areas every summer. Potential growth of wood products on what may in future be termed commercial forest land of the Interior is no small item.

On an estimated 40 million acres that are considered to be commercial forest land there are some 350 billion board feet, or perhaps 700 million cords of wood. Possibly some burned-over land not now considered commercial would be productive if protected and allowed to restock naturally. Just one severe fire, or even repeated light fires, means waiting about 160 years for another crop of timber. When Alaskans finally discover that this timber, properly manufactured, could be one of the most valuable resources in Alaska, forest fires will be viewed with more than mild concern.

Before a resource can be developed it has to be protected. Good headway is being made by the Bureau of Land Management's Forestry Division, but more active support by the people of the Interior is needed and this can come only with a realization of the values being damaged or destroyed.

This paper is a summary of a report by Professor H. J. Lutz of the Yale Forest School who conducted the study under the direction of the Alaska Forest Research Center and with the cooperation of the Forestry Division of the Bureau of Land Management.

Two things stand out in the Lutz report: (1) the Interior forests are <u>not</u> all stunted, slow-growing arctic stands. Large areas of forest in the Interior have as high a volume as stands in northern Maine and southern Ontario where great industries depend on them; (2) fires do a lot more damage than just destroying the timber. They damage the beauty of the landscape for tourists, they create a smoke nuisance that makes flying dangerous and they destroy wildlife habitats of many valuable fur bearers. They are apt to reduce the water supply for mining and when repeated on the same areas, turn a forest into permanent grass and brush.

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ECOLOGICAL EFFECTS OF FOREST FIRES IN THE INTERIOR OF ALASKA

by

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U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

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ECOLOGICAL EFFECTS OF FOREST FIRES

IN THE INTERIOR OF ALASKA

by H. J. Lutz[1]

INTRODUCTION

Some 60 percent of Alaska's land area, or about 219 million acres, is in the Interior. In this vast region tree growth is the dominant vegetation on much of the area below an altitude of about 2500 feet, but it is absent or very scanty on the flat, excessively wet lowland situations which are variously designated as muskeg, tundra, or bog.

About 125 million acres bear sufficient tree growth to justify designation as forest land. This great, predominantly coniferous forest has its counterpart in northern Canada, the Scandinavian countries, and northern Russia; it is analogous to the taiga of Siberia. It represents a tremendous potential source of wood and cellulose and possesses high value as a habitat for wildlife. Occurring, as it does, in a region where precipitation is low and runoff is high, this forest also has significance in terms of hydrologic relations.

The forests of Interior Alaska, in common with all forests of the North, are very susceptible to destruction by fire. Lightning is one of the causes of fires but man is chiefly responsible. Fires in the North may burn for weeks or months, spreading over areas reckoned in hundreds of thousands or even millions of acres. The reasons for the extensive spread of fires are numerous, among which may be mentioned lack of detection until of large size, lack of effective natural barriers to the spread of fire, high inflammability of the fuel, inaccessibility, and lack of sufficient manpower and equipment for fire suppression. In view of the direct and indirect importance of the forest resources involved, their extensive destruction by fire has become a matter of widespread concern.

The purpose of the present paper is to summarize the results of an investigation of the effects of forest fires on vegetation, soils, wildlife and hydrology in the Alaska Interior. Principal emphasis was placed on the effects of fires on the vegetation and soils. Field work was carried out during the summers of 1949, 1950 and 1951 and involved investigation of 103 sample plots, 11 transects and some 860 milacre quadrats. Plant collections made

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1/ Yale University and
Alaska Forest Research Center

during the course of the work included 375 species of higher plants, several liverworts, 70 mosses and 107 lichens. The field work extended from the Kenai Peninsula on the south to the Yukon River Valley on the north.

GEOGRAPHY OF THE ALASKA INTERIOR

THE REGION referred to as the Alaska Interior in this report embraces the vast country between the Brooks Range on the north and the Coastal Range, bordering the Pacific Ocean, on the south. Two major divisions may be recognized, one south of the Alaska Range, the other north.

The country between the Alaska Range and the mountains along the coast consists principally of the valleys of the Susitna, Matanuska and Copper Rivers, and their tributaries. All these rivers are fed by melt-water from glaciers and in consequence are choked with sediment.

Most of the Interior region lies north of the Alaska Range and south of the Brooks Range; this division includes chiefly the valleys of the Kuskokwim, Tanana, and Yukon Rivers, and their tributaries. Mention may also be made of the Kobuk and Noatak Rivers, both of which drain into the Arctic Ocean. In general the country may be characterized as a rolling upland, deeply dissected by well-developed drainage systems with stream valleys and broad lowlands. Rising above the general level are scattered mountain masses and isolated peaks. In their courses through lowland areas the large rivers meander through numerous channels. With few exceptions the streams are heavily laden with silt derived from glaciers and from bank cutting.

CLIMATIC CONDITIONS IN INTERIOR ALASKA

THE INTERIOR OF ALASKA has a continental climate with great extremes of temperature. During the winter much of the Interior is characterized by relatively high atmospheric pressure and fair, cold weather. Aleutian low pressure systems may, however, move in over the Yukon Valley and when this occurs southerly winds cause a moderation of temperature and precipitation occurs. When the Arctic high pressure system builds up, fair and unusually cold weather, with northerly winds, results. In the summer the great land mass of the Interior region heats up under the influence of nearly continuous insolation and low atmospheric pressure prevails. The weather becomes warm, and even hot, with occasional precipitation.

Climatically, as well as geographically, two divisions may be recognized, one south of the Alaska Range and the other north. Climatic conditions in these two divisions differ, as the following comparison shows.

	South of the Alaska Range	North of the Alaska Range
Average annual precipitation, inches	15-20 (One-third during May - August)	10-15 (One-half during May - August)
Mean temperature, July, ^{o}F.	52-57	55-60
Mean temperature, January, ^{o}F.	5 to 10	-10 to -20
Temperature extremes, ^{o}F.	-36 to 92	-78 to 100
Length of growing season, days	72-110	54-90

THE FORESTS OF INTERIOR ALASKA

SEEN FROM THE AIR the forest and other vegetation cover appears as a complex mosaic of types. In general, the forest occupies the valleys, often appearing as belts which follow the meanders of the streams, and the lower slopes and low benchlands. Throughout most of the region timberline is comparatively low, between 2000 and 3000 feet elevation.

The complexity of the vegetation pattern is, in large measure, the result of fire. Only when the influence of past fires is appreciated can one begin to account for the seemingly haphazard distribution of vegetation types. The sharp boundaries between stands of quaking aspen or Alaska white birch and white spruce are then recognized as the edges of burns. Isolated stands of a few acres of white spruce, the upland stringers and even the scattered trees of white spruce, may then be demonstrated to represent remnants or relicts of former extensive stands that have been destroyed by fire. Areas now treeless, on close examination prove to have formerly supported full forest stands which were destroyed by repeated burning.

Another influence that contributes to the diversity of vegetation cover is the occurrence, in somewhat complicated pattern, of permanently frozen ground. This phenomenon frequently results in poor soil drainage with the attendant evils of poor soil aeration, restricted root space and low soil temperatures. Within the Alaska Interior, either greatly impeded drainage (whether associated with permanently frozen ground or not) or very excessive drainage lead to outstandingly poor sites for tree growth.

Sharp boundaries between vegetation types are most frequently caused by fire whereas those caused by topography and associated influences are apt to be diffuse.

The principal forested regions of the Interior south of the Alaska Range include the following, from east to west: the Copper River and its many large tributaries, the Matanuska River, the Susitna River and its tributaries, upper Cook Inlet (including the west side of the Kenai Peninsula), and the Iliamna Lake-Lake Clark and Nushagak River sections. North of the Alaska Range, forest cover occurs extensively in the Kuskokwim, Tanana and Yukon River regions. It is noteworthy that considerable areas of forest occur north of the Arctic Circle, for example, on the Porcupine River and its tributaries, the Chandalar, the upper Koyukuk, and the Kobuk Rivers. Tree growth is known to occur well north of latitude 68° N. on the south slopes of the Brooks Range and as far west as the Niukluk River, near Council, on the Seward Peninsula. This latter station is the westernmost occurrence of forest growth on the American continent.

The view is sometimes expressed that the trees of the Interior are all small and scrubby, and that their growth is excessively slow. This generalization is wholly unwarranted and may be based, where there is any basis at all, on observations along roadsides where burning has usually been most frequent. In mature stands of spruce, diameters of 18-24 inches have been observed repeatedly and occasionally trees as large as 36 inches in diameter have been recorded. Maximum heights are around 100 feet.

The general situation as regards forest areas and wood volumes (all of which are rough estimates) in the Interior may be summarized as follows:

<u>Forest land area</u>	125 million acres
Commercial	40 " "
Open woodlands	85 " "
<u>Volume of wood</u>	350 billion board feet
	or 700 million cords

Plate 1. Landscape in the Copper River Valley showing a mosaic of vegetation types - white spruce, quaking aspen, and willow - which reflect the complex fire history of the region.

Plate 2. View of the Yankee-Ophir Creek fire, WNW of McGrath in the Kuskokwim River region. Dense clouds of smoke rose to heights of 20,000 feet and drifted over the Pacific Ocean some 500 miles to the south. The airport at nearby McGrath was closed in by smoke for days at a time. 1941. (Courtesy of R. R. Robinson, Bureau of Land Management.)

Average wood volumes in white spruce-birch types, trees	
5" diameter and larger to 4" top	2,400 cu. ft. per acre
7" diameter and larger to 6" top	8,000 ft. B.M. per acre
Probable volume of wood at rotation age of 160 years	3,900 cu. ft. per acre or 15,500 ft. B.M. per acre
Average age of stands studied	120 years

The above estimates of forest land acreage and growth and yield are based on the best data now available. In the future they may be found too high or too low. Even if they are substantially in error, however, it is certain that this forest resource will still be so great and so important to the future economy of Alaska that it will require consideration in the national program of forest conservation.

HISTORY OF FOREST FIRES IN INTERIOR ALASKA

THE EXTENSIVE and repeated occurrence of forest fires in the North in prehistoric, historic and modern time is a matter of fact. The record of occurrence in prehistoric times can be read in the forests themselves and the journals and reports of explorers and travellers, beginning with the earliest, continue the record to modern times.

Forests such as those in the Alaska Interior are peculiarly liable to destruction by fire. Relatively low precipitation, long hours of sunshine during the summer period and remarkably high air temperatures enhance the fire hazard in forests which, by their very nature,are readily inflammable. These forests are characteristically coniferous with relatively small trees, often with a heavy growth of "beard lichens". Fire carries readily in dense stands as it also does in open stands; in the latter the trees retain their branches to the ground and the intervening spaces are blanketed with a cover of mosses, lichens and small shrubs. In the summer the mosses and lichens become extremely dry and then possess a tinder-like quality.

In earliest times some fires were caused, as they are today, by lightning, but there can be little doubt that Indians were the major cause. Indians had the habit of using signal fires as a means of communication; they used smudge fires to relieve themselves of the scourge of mosquitoes; they burned out dense undergrowth to aid their hunting; and, being nomads, they were continually making campfires.

The tempo of forest destruction in Alaska was substantially increased when, in 1896, gold was discovered in the Klondike. There followed the fabulous stampede which brought thousands of people to the Yukon and to Alaska. From 1898 on to 1940, when the Alaska Fire Control was organized, an average of at least one million acres was burned over each year. During single bad fire years, as for example 1915, several million acres were burned. Railroad and highway construction, in their time, also led to a rash of fires, many of them being among the largest the territory has suffered.

In summary, it may be said that most of the fires have been caused by man. Many have started as a result of general carelessness and many have been caused intentionally. The reasons advanced for intentional burning are numerous but the most common are: to increase moose feed, to increase grass for forage, to kill mosquitoes and other insect pests, to make prospecting easier and to provide dead wood for fuel.

EFFECTS OF FIRES ON FOREST TREES

THERE ARE NO TREES in Interior Alaska that can live through severe fires. None, with the possible exception of tacamahac poplar, have bark sufficiently thick to withstand the high temperatures that are generated, especially around the basal portions of the boles. This statement is confirmed by the fact that living trees with fire scars are uncommon. Only rarely are such trees encountered and then almost invariably they are located at the extreme edges of burned areas where the intensity of the fire was low. Ecological differences in the species do occur, however, and some of them are of importance from the standpoint of reaction to burning.

White spruce

White spruce is probably more susceptible to destruction by fire than any other tree in Alaska. The trees have thin, easily damaged bark and the living branches of the crown often extend nearly to the ground. Being shallow-rooted, the species is severely affected by slowly burning, hot surface fires in the deep forest floor. Mounds of cone scales 10 to 12 feet in diameter and 1 to 2 feet in depth around the bases of occasional trees provide fuel for unusually hot local fires.

The species is often at a disadvantage in seeding burned areas because it does not bear seed at as early an age as most of its associates. Further, it is often present as an understory under Alaska paper birch or quaking aspen and hence is not capable of seed production. Fires are especially destructive of white spruce seed

for, unlike black spruce, the cones open on maturity and the seed is disseminated. Following a fire in white spruce, regeneration of the species most generally comes from seed blown in from adjacent unburned areas. Although white spruce is a tolerant species, being able to survive for long periods under the shade of, and in competition with, overstory vegetation, it reproduces excellently on bare mineral soil following fires and makes good growth when exposed to full solar radiation.

Black spruce

When growing on upland soils black spruce is fully as susceptible, or more susceptible, to destruction by fire as is white spruce. Extensive upland areas of black spruce are occasionally seen where a fire has killed literally every tree. On relatively wet lowland areas the likelihood of complete destruction of stands is much less. There individual trees, and trees in irregular groups and stringers, are likely to survive. This is important because a continuing source of seed is thus provided for restocking. Many, if not most, of the seedlings of black spruce that appear in burned-over areas originate from seeds that were present in unopened cones on the trees at the time of the fire. Seed production in the species appears to be earlier and more regular than in white spruce; failures in seed crops seem to be infrequent.

Under normal conditions not all seeds are shed from black spruce cones for two to three years following maturity. As a result of this habit, black spruce trees, at any given time, usually retain in "storage" very considerable amounts of viable seeds. This supply of seed, stored on the trees near their tips, is seldom completely consumed even in severe crown fires. The outer portions of the cone scales may be charred but the seed remains viable and, in large measure, accounts for the abundant regeneration that usually develops. The behavior of black spruce following fires is analogous to that of certain other "fire species", notably jack pine, lodgepole pine and pitch pine.

Black spruce, like white spruce, is relatively tolerant of shade and competition from other vegetation. However, regeneration is most abundant and seedling growth most rapid on mineral soil receiving full, or nearly full, solar radiation. Under forest conditions black spruce reproduces regularly by layering of basal branches. The group-wise occurrence of black spruce, perhaps seen most dramatically from the air, is the result of vegetative regeneration.

Paper birch

Alaska paper birch (Betula papyrifera var. humilis) appears to be the most common tree birch in the Interior of Alaska. On the Kenai Peninsula the Kenai paper birch (Betula papyrifera var. kenaica) is the chief species. Ecological differences between varieties were not perceptible to the writer so no further distinction will be made.

Birch is readily killed by fire when young because of the relatively thin bark. In later life the bark becomes thicker but it is then also more inflammable, as it begins to exfoliate. The tinder-like quality of birch bark is well known. It appears that more birch trees survive in burned-over areas than is the case with white spruce. The principal reason is that the forest floor under birch trees, and in birch stands, is not as deep as under white spruce, with the result that surface fires generate less heat and are less persistent.

Regeneration by sprouting from root collars of fire-killed birches is frequently seen in young stands. Sprouting in middle-aged and old stands is less frequent. The sprouts arise from dormant buds around the base of the stump and contribute to restocking. Regeneration from this source is not, however, as important as is seedling reproduction.

Birches produce seed at an early age and seed production in middle-aged and mature trees is evidently very great. Birch seed is light and readily disseminated by wind; the species may be regarded as a rather highly mobile pioneer. Mineral soil seed beds and full solar radiation provide favorable conditions for initial establishment and subsequent rapid growth. Splendid dense stands of well-formed trees frequently follow fires if adequate supplies of seed are available.

Quaking aspen

Quaking aspen is killed by hot fires but in pure stands the fires are characteristically light. Conditions for decomposition of litter under quaking aspen stands are relatively favorable with the result that the accumulation of forest floor material is usually too light to carry a hot, persistent fire. In the great burn of 1947 on the Kenai Peninsula, green oases of quaking aspen were frequently seen surrounded by areas in which the spruce was completely killed. Stump sprouts from quaking aspen are uncommon but root suckers are extremely abundant. Areas that supported quaking aspen prior to a fire are almost certain to be regenerated to the same species as a result of root suckers alone.

Seedling reproduction of quaking aspen is also common. Seeds are borne in tremendous numbers and they are admirably adapted for widespread dissemination by wind.

Quaking aspen is a pioneer species. It is intolerant, characteristically develops in even-aged stands, and finds mineral soil exposed to full solar radiation favorable for establishment and subsequent development.

Tacamahac poplar

Tacamahac poplar is probably more resistant to destruction by fire than any other forest tree in the Interior of Alaska. Bark thickness, near the base of the bole, is often 4 or more inches on mature trees. As in quaking aspen stands, surface fires in the tacamahac poplar type tend to be light because of the relatively thin accumulation of forest floor material.

Regeneration by root suckers is common in stands through which fire has passed. Seedling reproduction is also abundant whenever mineral soil has been exposed and a source of seed is at hand. Like quaking aspen, tacamahac poplar is an intolerant species that produces tremendous quantities of seeds that are very easily and widely disseminated by wind.

The species is normally regarded as a pioneer tree on recently deposited alluvium along streams and on river valley situations subject to overflow. It is also known on upland areas where, as a result of fire, exposed mineral soil has provided an opportunity for the seeds to germinate.

FOREST SUCCESSION FOLLOWING FIRES

FOREST VEGETATION development following fires in the Interior of Alaska is neither a completely fortuitous, random process nor is it an invariable, highly orderly process closely directed by a mysterious, beneficient "Nature". Elements of the fortuitous do exist but so also are there elements of order.

The writer has found it convenient to employ the concept of climax vegetation in the sense of self-perpetuating, terminal plant communities of considerable stability. Two categories of climax vegetation are distinguished--climatic and physiographic. The climatic climax forest is regarded as the terminal stage of successional development on moderately well-drained uplands and the physiographic climax forest is regarded as the terminal stage on poorly-drained, relatively cold areas. From the standpoint of stability there is little difference between a climatic climax and a physiographic climax--for practical purposes both may be regarded as self-perpetuating, terminal communities.

As a result of fires the climax white spruce stands on moderately well-drained sites have been replaced, over wide areas, by stands of paper birch and quaking aspen. Both of these species have a shorter span of life than white spruce, both have shorter pathological rotations and in neither the paper birch type nor the quaking aspen type can timber be stored on the stump as it can in white spruce forests. Fires have had less effect in changing forest composition on the forested lowland areas where black spruce represents a physiographic climax. In the absence of repeated burns, occurring at short intervals, black spruce tends to perpetuate itself. The outstanding effect of fires is that vast amounts of existing timber are destroyed and that the representation of subclimax types is greatly increased.

In the pages which follow the plant communities encountered in the forested regions of the Alaska Interior will be described and the course of successional development indicated. A schematic representation of the changes in various forest types following fires is presented in Figure 1.

Recently burned areas, currently regenerating

Included in this category are those areas so recently burned that the vegetation cannot, at this time, be assigned to specific forest types or plant communities. They are in a stage of very rapid change, with the site only partially occupied and with new plants entering each year. Areas in this class were usually burned over less than 10 years ago.

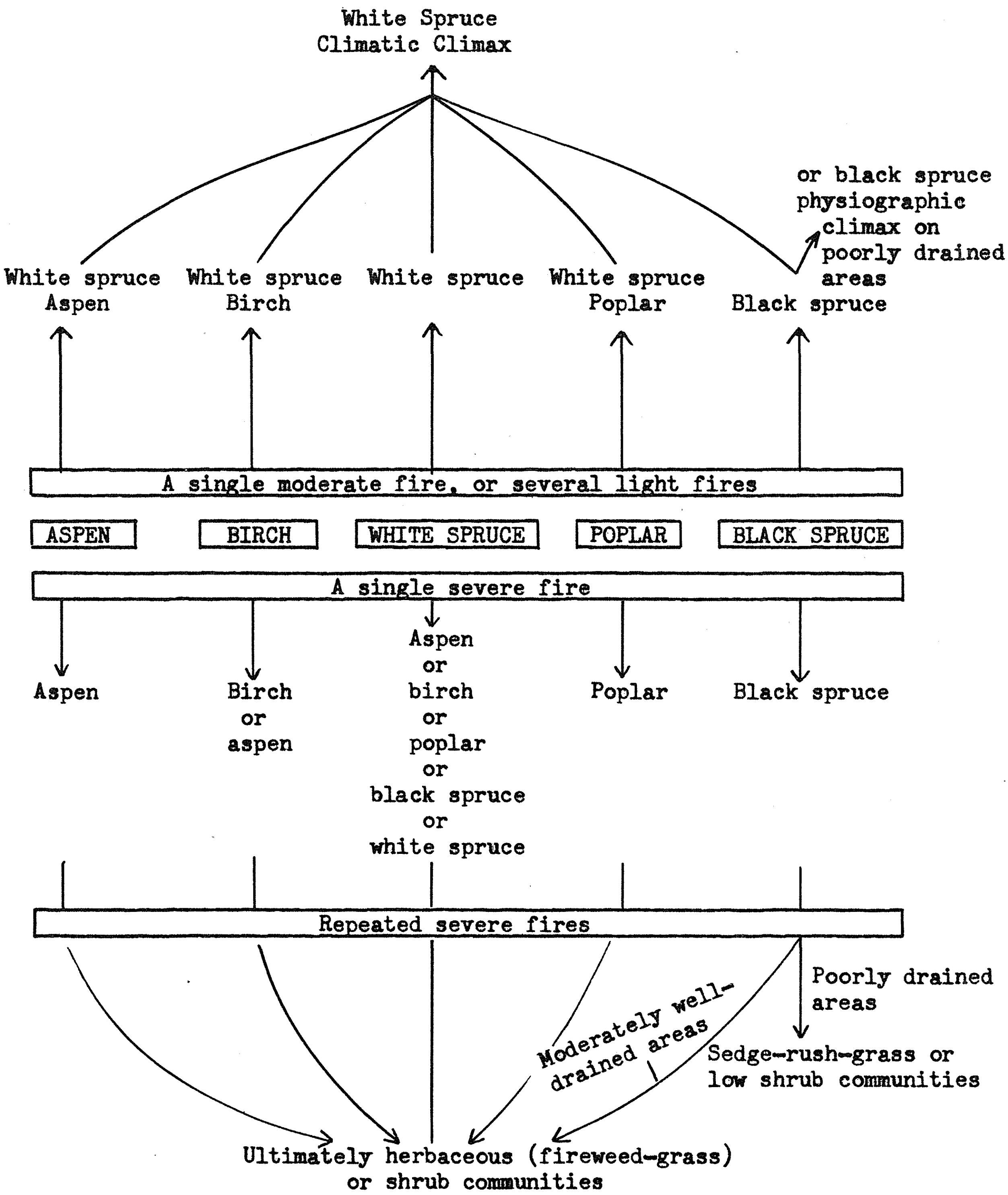
The two most important conditions that influence development of seedlings in recently burned areas appear to be (1) the presence of viable seed and (2) exposed mineral soil.

Establishment in burns of seedlings of plants having fleshy or pulpy fruits tends to be relatively slow for they are dependent on animals for dispersion. These agents of dispersion are not very abundant in burned areas, at least for several years following a fire. On the other hand, species that produce light, wind-disseminated seeds are very common in the early stages of revegetation. The fireweeds and willows are good examples of such species.

Mineral soil is a more favorable seedbed than charred organic matter because of a more stable moisture supply, somewhat lower surface temperatures and a greater supply of readily available plant nutrients. The high importance of mineral soil for seedling establishment is observed repeatedly. The extent to which mineral soil is exposed by fire will, of course, vary in time and place. In the recently burned spruce areas examined, mineral soil was exposed over about one-third of the surface. Burning tended to be more intense on ridges than in valley situations, and slopes with

Figure 1.

Schematic representation of changes in various forest types following fires of various intensities



south or west exposures commonly had more mineral soil exposed after a fire than did slopes with north or east exposures. Fires are often unusually severe on rocky slopes or ridges. More noticeable than any influence of topography or exposure, however, was the effect of the trees themselves on the pattern of burning. Fires burn more deeply _under_ trees than in the space intervening _between_ trees. The periphery of a given deeply burned area often coincides approximately with the crown projection of the tree concerned. The explanation for this situation is that the driest points in a spruce forest are under tree crowns, which intercept both rain and snow. Further, accumulations of cone scales are often found under spruce trees. In paper birch, quaking aspen and tacamahac poplar stands, burning is usually less intense than in spruce and consequently less mineral soil is exposed.

Tree reproduction usually appears in burned forest areas within one year after a fire. In the recently burned areas examined, all swept by fire one to ten years previously, the total number of tree seedlings per acre averaged around 15,000. With the process of regeneration continuing, new forest stands will follow those destroyed.

Shrub reproduction consists predominantly of willows, _Salix Bebbiana_, _S. Scouleriana_, _S. arbusculoides_ and _S. Barclayi_ being most common. Of the shrubs other than willows, _Cornus canadensis_, _Rosa acicularis_, and _Vaccinium Vitis-idaea_ are most common. The predominant grasses on recent burns are _Agrostis scabra_, _Calamagrostis canadensis_ and _Festuca altaica_. Of the non-grasslike herbaceous plants _Epilobium angustifolium_ is most abundant, often attaining densities of 50 percent. It is present on practically every area that has been recently swept by fire.

Mosses are limited to a few species, the most common of which is _Ceratodon purpureus_. Often this species attains a density of cover approaching 100 percent where mineral soil has been exposed. The liverwort _Marchantia polymorpha_, like _Ceratodon_, is a fire species and enters burned areas within the first two years following fires. Locally it may attain a density of 100 percent. Lichens are rare on burned forest areas for the first ten years. Occasionally _Peltigera canina_ var. _rufescens_ and _P. canina_ var. _spuria_ are seen after the fourth or fifth year. The fruticose "reindeer lichens" seem to be completely absent in forest areas recently burned; their return is very slow, often requiring as much as 40 years.

Paper birch type

This type represents a relatively early stage in forest succession, comparable to the quaking aspen type. Stand boundaries are usually sharp, as would be expected in view of the fact that they usually

mark the periphery of a fire. Characteristically the type is pure but occasionally aspen, and rarely tacamahac poplar, appear in the main crown canopy. Scattered white spruce, occurring in the understory, are frequently encountered in stands more than 80 years of age, as also are thinleaf alder and Sitka alder. Initially stand density is very high with 3000 to 6000 trees per acre not uncommon at 20 years. After an age of 100 to 120 years is reached the paper birch declines and the white spruce increases. Defect in the form of frost cracks in the boles of the larger trees and decay, apparently due chiefly to Fomes igniarius nigricans, become increasingly noticeable after the stands attain an age of about 100 years. Maximum heights in the examples of mature or overmature stands that were examined seldom exceeded 80 feet; maximum diameters were seldom over 18-20 inches.

Tree reproduction is scanty and willows, such as Salix Bebbiana, S. Scouleriana and S. Barclayi var. rotundifolia, are poorly represented in most paper birch stands. The most abundant shrubs, other than the willows, are the following: Cornus canadensis, Ribes triste, Rosa acicularis, Vaccinium Vitis-idaea, and Viburnum pauciflorum. One grass, Calamagrostis canadensis, is prominent in the birch type. The most abundant mosses are Hylocomium splendens, Pleurozium Schreberi and Polytrichum commune. Lichens, especially the fruticose "reindeer lichens", are scarce.

Paper birch, in essentially pure stands, is a fire type. The species seeds in on burned areas and even-aged forests result. Seedbed conditions under full stands of paper birch appear unfavorable for germination and initial survival of the species. It also appears that solar radiation under birch canopies is not favorable for seedling development. No evidence was seen that would indicate that birch will follow birch in successive generations in the absence of fire or other catastrophic disturbance. Barring disturbances such as fire, paper birch stands are gradually converted into white spruce-paper birch forests.

Fires in paper birch forests tend to perpetuate the birch and reduce the representation of white spruce.

White spruce - paper birch type

The white spruce-paper birch type represents a stage in succession comparable to the white spruce-quaking aspen type. It is more advanced than the paper birch, the quaking aspen or the tacamahac poplar types. Stands of white spruce-paper birch are of widespread occurrence on the uplands, probably occupying more area than does the paper birch type. Type boundaries are more diffuse than in pure paper birch stands; transition to pure birch or pure white spruce is frequently observed.

Plate 3. A pure stand of Alaska paper birch 55 years of age. Average diameters of dominants range from 4-9 inches; the heights range from 50-60 feet. This stand followed fire in a white spruce forest; spruce snags 12-16 inches in diameter are found on the ground.

The relative proportions of the two dominants, white spruce and paper birch, varies from stand to stand. This results partly from the fact that in some stands the spruce became established at the time the birch seeded in, whereas in other stands the birch came in first and the spruce later developed under the tree canopy. In no instance does birch invade stands that are initially pure spruce. Quaking aspen is commonly present as scattered individuals in young stands but is poorly represented in forests more than about 120-140 years of age. California poplar, tacamahac poplar, Bebb willow and Sitka alder occur as minor species, chiefly in the understory in young stands. Initial densities are usually high with around 2500 spruce and birch trees per acre at 25 years of age. Mortality, especially in birch, is high with the result that the number of trees has declined to around 500-700 per acre at 100 years of age. The proportion of spruce increases during the life of the stand and exceeds the birch after an age of about 130 years. Defect due to decay in the birch is noticeable in stands around 100 years of age and becomes very prominent thereafter.

Maximum heights in the mature and overmature stands seldom exceeded 65-75 feet for spruce and 60-70 feet for birch. Maximum diameters in spruce seldom exceeded 13 inches and in birch 15 inches.

Reproduction of tree species is scanty as also are willows. Salix Bebbiana and S. Scouleriana were about the only willows represented. The most abundant shrubs, other than willows, are Cornus canadensis, Rosa acicularis, Vaccinium Vitis-idaea, and Viburnum pauciflorum. Calamagrostis canadensis is the only important grass in white spruce-paper birch stands. The most abundant non-grasslike herbaceous plants are as follows: Comandra livida, Dryopteris disjuncta, Epilobium angustifolium, Equisetum arvense, Goodyera repens var. ophioides, Linnaea borealis var. americana, Listera cordata, Lycopodium annotinum, Pyrola asarifolia var. incarnata, P. secunda, and Trientalis europaea ssp. arctica. As in the paper birch type, the most abundant mosses are Hylocomium splendens, Pleurozium Schreberi and Polytrichum commune. Lichens are poorly represented and poorly developed in the white spruce-paper birch stands. The only species at all commonly encountered is Peltigera aphthosa var. typica.

Paper birch is not a very favorable nurse crop for white spruce. Under birch canopies light conditions are almost certainly below the optimum for spruce. The result is that juvenile growth of understory spruce is slow. As the spruce crowns gradually enter the strata occupied by the birch, crown friction is encountered and many of the spruce leaders are deformed, often beyond recovery. Although conditions are not very favorable for development of spruce in birch stands they are even less favorable for birch reproduction. The destiny of white spruce-paper birch stands, in the absence of fire or cutting is gradually to change into relatively open, essentially pure, white spruce stands.

Plate 4. An Alaska paper birch-white spruce stand approximately 110 years of age.

Fires tend to perpetuate the birch and reduce the proportion of spruce, but not to the extent noted in the paper birch type. This is explained by the fact that the older, larger birch does not reproduce as well by sprouting as does younger, smaller birch and in most white spruce-paper birch stands the spruce is older and more likely to have begun to bear seed.

Quaking aspen type

The quaking aspen type represents a stage in succession comparable to the paper birch type. It commonly represents the first forest stage following fires. The type is very widespread in its occurrence and is particularly common on relatively dry slopes having a south or southwest exposure, and on other excessively drained situations. Excessive drainage, although evidently favoring quaking aspen more than white spruce or paper birch, generally leads to poor, slowly growing, rather open stands. Boundaries of quaking aspen stands are often very sharp, marking the peripheries of old fires.

Quaking aspen frequently has as associates white spruce, paper birch, and tacamahac poplar but representation of these species is usually poor and bears no discernible relation to site. In the understory may be found Bebb willow, Scouler willow, littletree willow and American green alder. It appears that the willows are most common in young stands, that is, those less than about 40 years of age. Initial densities in quaking aspen stands are high, 3000-6000 stems per acre being found at ages of 20-25 years. Even in stands 50-60 years of age there are frequently 1000-3000 stems per acre. After the stands attain an age of about 60 years, decay becomes very common and they start to open up as the trees die.

Maximum heights in the oldest stands classified as pure quaking aspen seldom exceeded 60 feet and maximum diameters were seldom more than 10 inches. These values, however, do not represent the maximum sizes attained by quaking aspen in the Interior of Alaska.

Aspen stands are essentially even-aged but as they pass into the white spruce-quaking aspen type they tend to become uneven-aged.

Birch reproduction is almost lacking in quaking aspen stands and white spruce reproduction tends to be sparse unless a good seed source is at hand. Of the willows, Salix Bebbiana is most abundant especially in young forests. The most abundant shrubs, other than willows, are Arctostaphylos Uva-ursi, Rosa acicularis, Shepherdia canadensis and Vaccinium Vitis-idaea. A wider variety of grasses are found in quaking aspen communities than in the paper birch or white spruce-paper birch forests, presumably because of the more open canopies in most aspen stands. The more common grasses are Agrostis scabra, Calamagrostis canadensis, and Festuca

Plate 5. A quaking aspen stand approximately 65 years of age. The dominants are 6-11 inches in diameter and 65 feet in height. In 1947 a light surface fire entered this stand killing all understory white spruce, then 6-15 feet in height. Only occasional aspen trees were killed. Kenai Peninsula.

altaica. Of the non-grasslike herbaceous plants the most abundant are Achillea borealis, Epilobium angustifolium, Equisetum scirpoides, Linnaea borealis var. americana, and Mertensia paniculata. Mosses do not attain the density of coverage in aspen stands that they do in paper birch and white spruce forests. On the other hand, the lichen population in aspen stands is considerably greater than in either the paper birch or white spruce-paper birch types. Perhaps this may be explained by the fact that the aspen communities are usually more open.

Quaking aspen stands develop following fires. Regeneration is from seedlings and root suckers with stump sprouts representing a usually unimportant component. Abundant vegetative reproduction from root suckers almost invariably follows on burned areas where the previous stand contained aspen. Aspen seeds are borne in large numbers and are easily disseminated but even so fairly close proximity to a seed source seems essential to the establishment of seedlings in quantity.

In the absence of fire or other comparable disturbance, aspen does not follow aspen; a possible exception may be found on excessively dry slopes having a southerly or southwesterly exposure. In such situations quaking aspen seems to be a relatively stable type. On the majority of sites aspen is replaced, in the course of time, by white spruce.

Fires in aspen stands perpetuate aspen and destroy practically all the white spruce that may be present in the understory.

White spruce-quaking aspen type

This type represents a stage of successional development directly analogous to the white spruce-paper birch type. It is widely represented on the uplands of the Interior, perhaps being most common on relatively dry slopes having a south or southwesterly exposure and on excessively drained outwash or deltaic soils. On the drier situations entry of white spruce into aspen stands is slower and subsequent development is less rapid than on sites with favorable moisture relations.

The relative proportion of white spruce and quaking aspen varies substantially from stand to stand. Reasons for this usually relate to the composition of the reproduction at the time the original stand was established or to the rate of subsequent entry of spruce. Associated species are tacamahac poplar and several willows, of which Salix Bebbiana is usually the most important. Initial stand densities are high with 1000-2000 white spruce and quaking aspen stems per acre. By the time the stands have attained an age of around 100 years the number of stems per acre has declined to around 400-600. White spruce gains in importance with increase in stand age whereas the importance of quaking aspen declines.

Maximum heights in mature and overmature stands seldom exceeded 60-70 feet for spruce and 65-75 for quaking aspen. Maximum diameters in spruce and aspen were seldom more than 10-12 inches.

The white spruce is uneven-aged in most stands whereas the aspen is essentially even-aged. The spread of ages in spruce increases with increase of stand age.

White spruce reproduction is present in all stands but the number of trees per acre tends to be low, averaging about 1100. Aspen root suckers arise but most of them die after a few years. Birch and tacamahac poplar reproduction is very scanty.

The most abundant shrubs are Arctostaphylos Uva-ursi, Cornus canadensis, Rosa acicularis, Shepherdia canadensis and Vaccinium Vitis-idaea. The most prominent grass is Calamagrostis canadensis, occurring most commonly in young stands. Of the non-grasslike plants the most abundant are Epilobium angustifolium, Linnaea borealis var. americana, and Pyrola secunda. Mosses are more prominent here than in the pure aspen forest. The most abundant species are Drepanocladus uncinatus, Hylocomium splendens, and Polytrichum commune. Of the lichens, Peltigera aphthosa var. typica and P. aphthosa var. variolosa are most abundant. The reindeer lichens are scarce.

White spruce-quaking aspen forests may become established immediately after fires but more characteristically they arise as a result of successional development with the spruce gradually invading essentially pure aspen stands. In the absence of fire, or comparable disturbance, spruce gradually replaces the aspen and relatively open spruce stands finally result.

Fires in the type are far more destructive of spruce than of aspen. Among the reasons for this are that the spruce is unable to reproduce by sprouting, has thin bark, and the inflammable foliage is carried well down toward the ground. On the other hand, the rapid height growth and early seed production of the aspen root suckers give this species an advantage. Severe fires in the type usually lead to pure aspen stands with most of the reproduction of root sucker origin.

Tacamahac poplar type

Tacamahac poplar in essentially pure stands forms a forest type which is characteristic of recently deposited alluvium and is found along most of the larger rivers and streams in the Interior of Alaska. Many stands represent the first forest stage in a primary successional series. Occasionally tacamahac poplar spreads from its characteristic stream valley habitat to adjacent upland sites which have been swept by fire.

The type is often pure but frequently white spruce appears as an important element, especially in old stands. Small understory species such as Sitka alder, American green alder, thinleaf alder, and littletree willow, feltleaf willow and Scouler willow are occasionally encountered. Initial densities are often high, with as many as 3500 trees per acre at 25 years of age. Density remains high even in mature forests. Decay appears to be common in old stands.

Maximum heights of tacamahac poplar in the stands studied do not exceed about 70 feet and diameters about 36 inches. However, it is known that much larger trees (up to at least 6 feet in diameter) occur in some of the better stands in the Susitna River Basin.

Reproduction of tree species is generally sparse with only occasional white spruce, tacamahac poplar and paper birch seedlings being encountered. <u>Epilobium</u> <u>angustifolium</u> is probably the most abundant herbaceous plant. Mosses and lichens are relatively unimportant.

The successional position of the tacamahac poplar type is not clear. That it characteristically develops on recently deposited alluvium is evident but less certain is the permanence of the type. Stands may be seen where white spruce is gaining dominance and will, in time, replace the poplar. Other situations are seen where the poplar appears to be a self-perpetuating community without any clear trend toward replacement by spruce or other species. Perhaps tacamahac poplar can occupy flood plain areas indefinitely if they are subjected to periodic overflow with deposition of silt or other alluvium.

Fires are not nearly as common in the tacamahac poplar type as in other forest communities but they are not unknown. The very thick bark on the poplar (4 or more inches in thickness on mature trees) renders the species more resistant to fire than any other Alaskan forest tree. Following fires the type regenerates by root suckers and seedlings in much the way that aspen does.

<u>White spruce type</u>

The white spruce type is the climax forest community on upland areas in the Interior of Alaska. It is of widespread occurrence and is primarily responsible for the vegetational aspect of the landscape. Only in regions which have escaped recent fires is the cover of spruce forest complete; commonly it is broken by more or less extensive areas of paper birch or aspen or types transitional between these and pure spruce. Type boundaries are usually sharp, marking the edges of fires. These boundaries between white spruce forest and aspen or paper birch forest are a common feature and appear as distinct lines that may be seen for miles.

Plate 7. A mature stand of tacamahac poplar containing trees having diameters of 36-48, or more, inches. This stand is similar to many of the flood-plain forests in the Susitna and Matanuska River basins. Adjacent to the Kashwitna River, in the Talkeetna Mountains.

Generally the type is pure, with only occasional representatives of black spruce, paper birch and tacamahac poplar. Understory species of small trees or large shrubs include several willows and alders. Bebb willow is the most abundant member of the group with 2000-3000 stems one inch in diameter, or larger, per acre in young stands up to 20-30 years of age. With increase in stand age the number of stems of Bebb willow decreases until they become very sparse in stands more than 160 years old. Other willows attaining diameters of one inch, or more, at breast height include littletree willow, feltleaf willow, Scouler willow and *Salix glauca* var. *Alicaea*. Like Bebb willow, the above species are most abundant in young stands and become scarce in forests more than 160 years of age. Sitka alder and American green alder, unlike the willows, are most common in old stands.

Initial stand densities are commonly high with 2000-3000 stems one inch in diameter, and larger, per acre in stands around 20-25 years of age. With increasing age the number of trees declines but even at 160-180 years there are usually 300-500 per acre. At this age 100-150 trees per acre have usually attained diameters of 10 inches, or more.

Maximum heights in the oldest spruce stands seldom exceed 85-100 feet and maximum diameters are seldom more than 20-24 inches. Average values are considerably less.

The forests may be either even-aged or uneven-aged, depending on their history. Stands that resulted from seeding in on burned areas are usually even-aged whereas the uneven-aged condition is more common in stands originating as a result of entry of spruce into other forest types, principally paper birch or quaking aspen. In all cases the representation of age classes increases with increasing stand age. Tree reproduction in most white spruce stands is predominantly spruce.

The most abundant shrubby species, exclusive of the willows, are *Arctostaphylos alpina* ssp. *rubra*, *Cornus canadensis*, *Empetrum nigrum*, *Ribes triste*, *Rosa acicularis*, *Rubus pedatus*, *Vaccinium Vitis-idaea*, and *Viburnum pauciflorum*. Grasses are scarce in white spruce stands less than about 120 years of age; *Calamagrostis canadensis* is by far the most prominent species, occurring widely but sparsely. Of the grasslike plants, *Carex concinna* is most frequently encountered. Non-grasslike plants of considerable variety are encountered. The most abundant are *Comandra livida*, *Dryopteris disjuncta*, *Epilobium angustifolium*, *Equisetum arvense*, *E. pratense*, *E. scirpoides*, *Goodyera repens* var. *ophioides*, *Linnaea borealis* var. *americana*, *Listera cordata*, *Lycopodium annotinum*, *Mertensia paniculata*, *Pyrola asarifolia* var. *incarnata*, *P. chlorantha*, *P. secunda*, and *Trientalis europaea* ssp. *arctica*. Mosses are characteristic of the ground vegetation in white spruce

stands. The species most prominent are Hylocomium splendens, Pleurozium Schreberi, Dicranum fuscescens, Drepanocladus uncinatus, Polytrichum commune, and P. strictum. The most abundant lichens are Peltigera aphthosa var. typica, P. aphthosa var. variolosa and P. membranacea. Certain of the reindeer lichens are commonly encountered, as follows: Cladonia rangiferina, C. sylvatica, and C. mitis. Many other lichens also occur occasionally. In the older stands certain "beard lichens", notably Usnea comosa ssp. eucomosa and Alectoria jubata are seen hanging from the tree branches. On the Kenai Peninsula and in the Talkeetna Mountains the large lichen Lobaria pulmonaria is also frequently observed in masses on the trees.

Single light surface fires in the white spruce type do not result in complete destruction of the stand nor do they induce important changes in stand composition. Openings are created, however, and in these seedlings of paper birch, and occasionally willows and quaking aspen, appear.

Single severe fires generally result in complete destruction of existing stands and replacement by communities dominated by sub-climax species. Composition of the new stand is primarily dependent on the seed sources adjacent to the burned area. If the area burned was extensive, and if all white spruce seed trees are killed, the reproduction will consist largely of quaking aspen, paper birch or tacamahac poplar. All these species are abundant seed producers and their seeds are widely disseminated by wind. If aspen trees were present in the stand destroyed it is certain that the species will be heavily represented in the new stand for aspen reproduces abundantly by root suckers. Black spruce is sometimes strongly represented in the reproduction that follows fire in white spruce on upland areas. This results when a good supply of black spruce seed is available. Occasionally reproduction of essentially pure white spruce may follow fires. This occurs most frequently when the burned areas are relatively small and are surrounded by, or are adjacent to, living trees of seed-bearing age.

Shortly after a fire has swept through a spruce forest, the dead trees begin to fall, creating a tangle of inflammable material that is difficult to penetrate. The result is that the fire hazard is greatly increased. Fire hazard, resulting from fallen snags, gradually increases for 5-10 years after a fire in timber, and then slowly decreases during the following 10-20 years. Rate of decay varies with aspect and ground conditions, as well as with size and kind of woody material, but in general it may be said that snags do not constitute much of a fire hazard after a period of 20-30 years has elapsed.

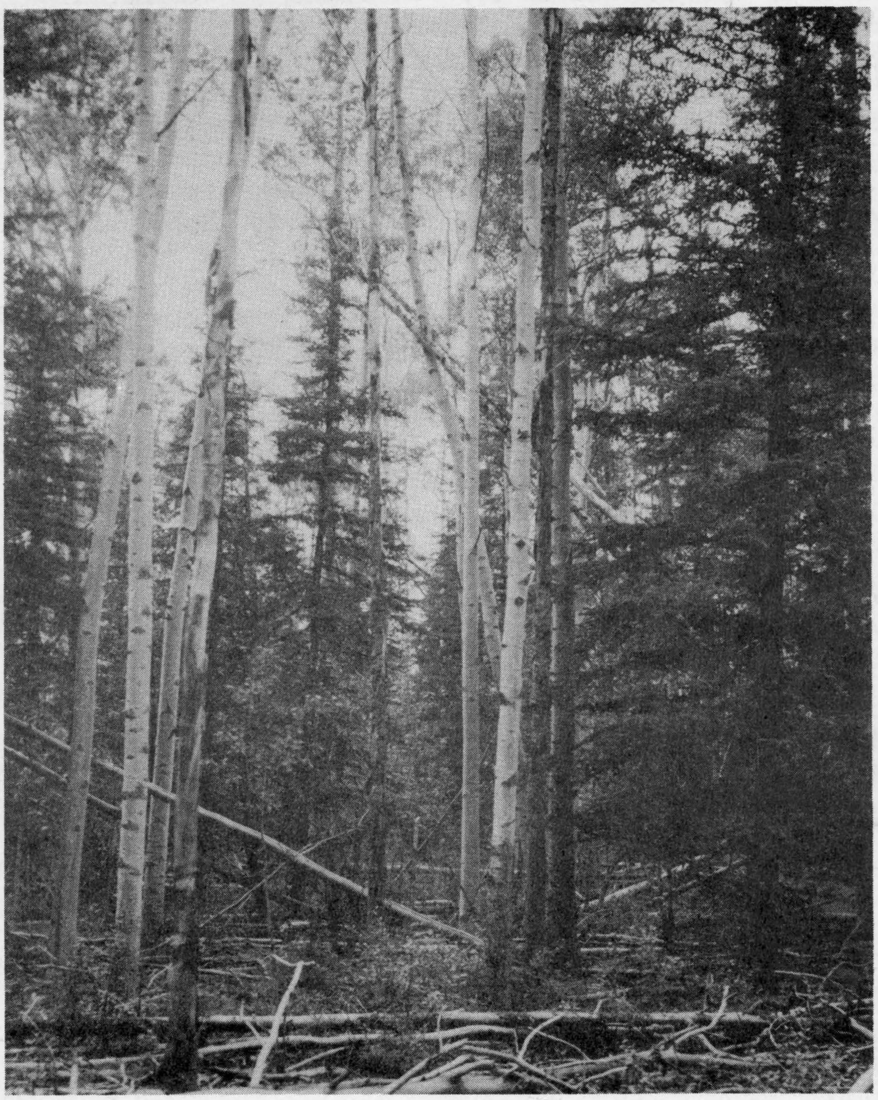


Plate 6. A quaking aspen-white spruce stand in which the dominant quaking aspen trees are approximately 115 years of age, 8-12 inches in diameter, and 60 feet in height. The white spruce trees have diameters of 5-11 inches and heights of 40-50 feet. Much of the quaking aspen is dead or decadent.

The frequency of burning has an important bearing on the composition of the plant communities that develop. Areas that once supported white spruce have been transformed to a treeless condition as a result of repeated fires. A dense cover of fireweed and grass (chiefly Epilobium angustifolium and Calamagrostis canadensis) now occupies tracts that previously supported forest. Fireweed-grass communities, when well developed, appear to be relatively stable; natural conversion to forest, where this occurs, evidently requires at least 100 years.

Another change in vegetation type that has occurred is from forest to a shrub cover of dwarf birch and willows. This community does not appear to be as stable as the fireweed-grass type; re-entry of tree species, especially spruce, seems to occur more readily.

The effects of fire are most severe on the poorest sites and it is here that recovery is most slow. It also appears that recovery from fire is dangerously slow at the upper altitudinal and latitudinal limits of forest growth.

Black spruce type

Black spruce usually occurs in situations where drainage is poor and the permafrost table is close to the surface. Stands of this species are commonly encountered in relatively flat valley bottoms, on cold slopes with a north exposure and on soils derived from clays and clayey glacial till. Black spruce in these situations represents an essentially stable, self-perpetuating, physiographic climax. Reproduction is by both seedling growth and by layering. Following fires, black spruce may also invade upland areas normally occupied by white spruce. On these sites it is regarded as a temporary "fire type" which will, in the course of time, give way to white spruce.

Characteristically, black spruce forms pure stands. Growing, as it usually does, in wet, poorly-drained habitats, competition from other trees is slight. Grayleaf willow and littletree willow occasionally attain a diameter of an inch or more and a height exceeding 6 feet but they are limited in occurrence.

Stand densities are very high in young stands, there often being 5000 stems one inch or more in diameter per acre in stands 30 years of age, or older. Even in stands 100 years of age, and older, there may be a total of 2000-3000 stems per acre, with 200-300 trees having diameters of at least 5 inches.

Maximum heights of trees in mature black spruce forests usually do not exceed 45 feet and maximum diameters are seldom more than 8-9 inches.

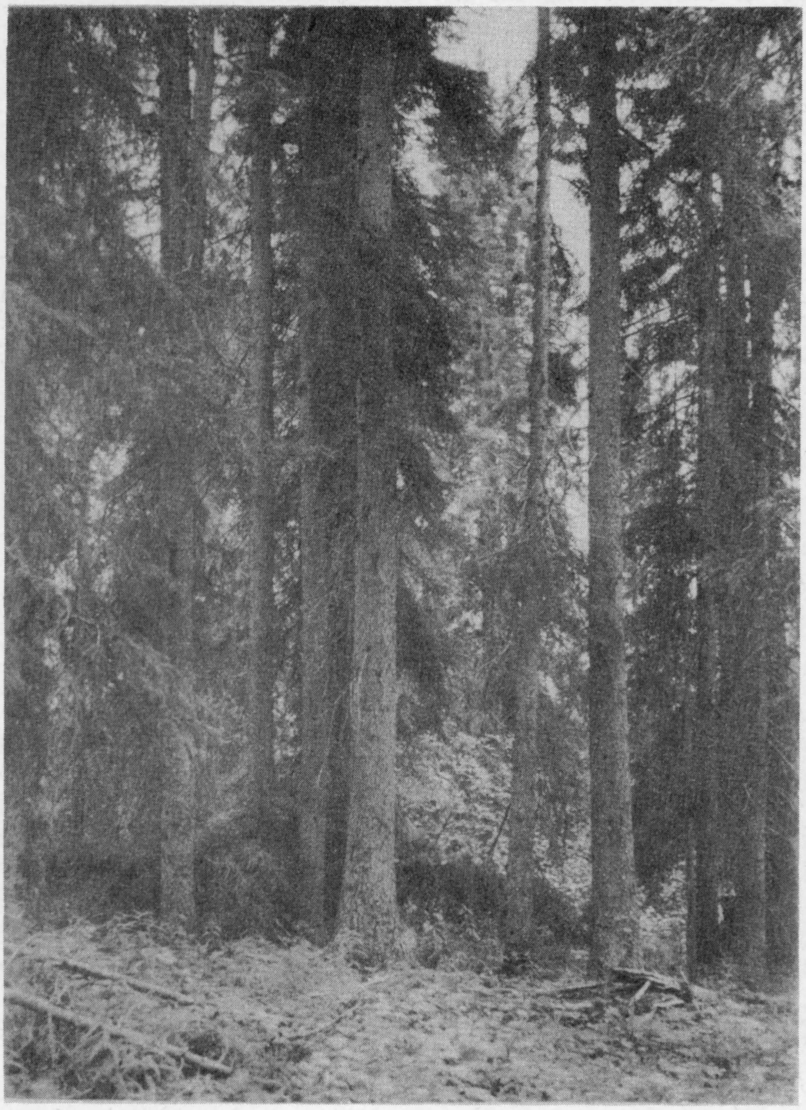


Plate 8. A climax stand of white spruce about 215 years of age. The dominants are 11-20 inches in diameter and 70-80 feet in height. There has been no fire in this stand during the life of the trees now standing.

Plate 9. About 26 years ago a fire swept through this area destroying a 75-year-old stand of white spruce. The snags still litter the ground and contribute to higher than normal fire hazard. Reproduction of white spruce is complete.

Young black spruce stands, originating following fires, are usually even-aged. In stands past 100 years of age, however, there is an increasing tendency toward unevenagedness. Tree reproduction is confined to black spruce. Practically all stands have tree reproduction established, with an average of around 4000 seedlings and layers per acre. Willows of all kinds (less than 6 feet in height) average around 4000-5000 stems per acre. Salix arbusculoides, S. Bebbiana var. perrostrata, S. glauca (with the varieties acutifolia and Alicaea), and S. myrtillifolia are among those most frequently encountered.

The most abundant shrubs, other than willows, are Arctostaphylos alpina ssp. rubra, Empetrum nigrum, Ledum palustre ssp. groenlandicum, Rosa acicularis, Vaccinium uliginosum and V. Vitis-idaea. Of the grasses, Arctagrostis latifolia is probably most frequently observed; Carex lugens appears to be the most common sedge. The most abundant non-grasslike herbaceous plants are Equisetum scirpoides, Petasites frigidus and Pyrola secunda.

Mosses are a characteristic component of the vegetation in the black spruce forest. They often completely cover the surface of the forest floor. Hylocomium splendens, Aulacomnium palustre, Dicranum Drummondii, Drepanocladus uncinatus, Pleurozium Schreberi, Sphagnum rubellum and Tomenthypnum nitens are among those most commonly represented.

A considerable variety of lichens occur but they do not, as a rule, occupy appreciable areas of the forest floor. The most common species are Cladonia coccifera, C. cornuta f. cylindrica, C. degenerans f. euphorea, C. gracilis var. dilatata, C. mitis and Peltigera aphthosa var. typica. In the old stands "beard lichens" such as Alectoria jubata and Usnea comosa ssp. eucomosa are of common occurrence on the trees.

Fires in black spruce are often intense, completely killing the vegetation and consuming the forest floor material. The high stand density and relatively low stature of the trees favor crown fires. The inflammability is often increased by the presence of "beard lichens" on the trees.

Following fires, black spruce usually regenerates to the same species. Repeated burning at short intervals of time may, however, result in replacement of black spruce by treeless communities such as sedge-rush-grass or low shrub.

Plate 10. A mixed forest of black spruce and white spruce 160 years of age. The largest black spruce trees are 6-8 inches in diameter and 30-40 feet in height; dominant white spruce trees are 8-12 inches in diameter and 50-60 feet in height.

EFFECTS OF FOREST FIRES ON SOILS

THE FOREST SOILS of Interior Alaska are shallow in the sense of soil development and also in a physiological sense. In coarse-textured soils drainage may be excessive with deficient soil moisture the result. On the other hand, fine-textured soils may retain excessive amounts of water leading to poor aeration and coldness. Organic matter tends to be unincorporated in the mineral soil, for the most part resting on it as a mantle. Under old white spruce stands, and especially in the black spruce type, the forest floor may attain a thickness of as much as 12 inches.

The degree to which the forest floor material is removed by fires varies with the intensity of the burn. It varies from slight charring of the uppermost litter to complete consumption down to mineral soil. In the recently burned areas examined, mineral soil was usually exposed over only 30 to 40 percent of the surface, even in fires so severe that all trees were killed. Practically none of the organic matter in the mineral soil is consumed.

Partial or complete removal of the forest floor by burning leads to increased soil temperatures. In undisturbed condition the moss and lichen cover is an effective insulator in the summer period. It is then dry during much of the time and effectively insulates the soil against entry of heat. Removal of the cover leads to higher surface temperatures and to downward retreat of the permafrost table. In general, the effects of fires on soil temperature are favorable from an ecological viewpoint. Moisture relations do not appear to be greatly altered as a rule, but on steep southerly slopes the effects may be unfavorable. Soil texture and structure, so far as is known, are not changed by burning.

Runoff on steep slopes is increased as a result of forest fires; the rate of infiltration is apparently reduced and the rate of overland flow is increased. Erosion by wind and water do not appear to be appreciably increased as a result of forest fires. The lack of extensive water erosion seems to be explained by the low total amount of precipitation, the normally low intensity of rainfall in individual storms, the long period each year that the soils are frozen and snow-covered, and the rapidity of revegetation of burned lands.

Chemical changes in forest soils resulting from fires appear to be ecologically favorable. Acidity is decreased, and exchangeable calcium and potassium and readily available phosphorus are increased. Although the total nitrogen capital of the site is reduced by fires which consume the forest floor material, the amount of nitrogen available to plants appears to be increased. Burning has an effect similar to fertilization. The nutrient capital in the forest floor, much of which may be regarded (both figuratively and literally) as

a frozen asset, is liberated in available form for use by the new plant growth. On the majority of forest sites the productivity of the mineral soil body does not appear to be reduced by burning. In fact, from the standpoint of the soil alone, it may be said that fires often have a favorable ecological effect.

EFFECTS OF FOREST FIRES ON HYDROLOGIC RELATIONS

EFFECTS OF FOREST FIRES on the hydrologic regime in Alaska cannot be stated with finality at this time. Available evidence does point, however, to an increase in the normal already high ratio of runoff to precipitation (55-65 percent, which is nearly 4 times as great as in temperate regions) and to increased amplitude between high and low water stages. Watersheds having steep slopes, from which the vegetation has been removed by fire, have been reported to exhibit very low minimum discharge rates and flashy runoff.

The problem of water supplies in the Alaska Interior will become more acute as population increases and the Territory is developed. Requirements for mining, for domestic use and for industry will become greater, not less. With increased demands and increased competition for water it seems certain that more attention will have to be given to the hydrologic role played by vegetation.

EFFECTS OF FOREST FIRES ON ANIMAL POPULATIONS

THE WILDLIFE of Interior Alaska is one of the important renewable resources of the region. From it both the white population and the Natives derive very considerable economic benefits. It is a resource that has great attraction for hunters and for the even larger number of tourists who merely wish to see and photograph wildlife in its natural environment.

Exceptions may occur but in general the effect of uncontrolled forest fires on the habitats of fur-bearing animals is unfavorable. The effect on the moose population is still a matter of some conjecture.

In certain areas following fires there quite evidently has been an increase of the moose population. It is only natural that this be interpreted in terms of cause and effect. Despite these examples, it may be doubted that the relationship is always a simple case of "more browse more moose". There are extensive areas in the Interior that have been burned repeatedly and which support much browse but few moose. Moreover records indicate that moose in Alaska have been moving westward and northward for over 75 years and that this movement has taken the animals into areas where burning has not occurred.

Good moose browse does not always follow forest fires. Spruce reproduction may appear in quantity and the more desired willows may not develop in numbers sufficient to withstand heavy use. It should also be recognized that establishment of browse species following severe fires is not immediate; years may pass before the burned areas again support an appreciable amount of food for moose. It may also be doubted that moose can reproduce rapidly enough to utilize fully the browse in extensive burns before it grows up out of their reach.

Accidental, uncontrolled forest fires can no more be justified in wildlife management than in forest management. If, in the future, it is ascertained that the objectives of management (either for wildlife or for timber) can most economically and effectively be attained through burning, then the use of <u>controlled</u> fire will be in order. The place, the time, and the intensity of the burn are all important considerations; surely these are more susceptible of management under controlled burning than when fires are accidental and hence uncontrolled.

The effects of fires on caribou are generally agreed to be harmful or even disastrous. This animal normally lives in environments characterized by climax communities, tundra and forest tundra. Fruticose lichens of the <u>Cladonia</u> group ("reindeer lichens"), together with certain "beard lichens" (<u>Usnea</u> and <u>Alectoria</u>) growing on trees, form the principal winter food of the caribou. These lichens are highly inflammable when dry and are thus readily susceptible to destruction by fire. Recovery is excessively slow. The length of time required for full recovery varies with the extent and intensity of the fires and site and microclimatic conditions, but an average of 40 to 50 years appears to be a conservative estimate. A half century, more or less, is a very long time for caribou range to be out of production.

EFFECTS OF FOREST FIRES ON THE FUTURE ECONOMIC DEVELOPMENT OF ALASKA

UNCONTROLLED FIRES, sweeping over large areas nearly every summer, place in jeopardy the future economic development of the Interior of Alaska. The area involved is vast but the resources that can be used in perpetuity, even under wise management, are relatively modest——certainly there is no excess that can be wasted.

Among the resources which, if wisely used, can support an economy in perpetuity, the forests with their great potential production of wood occupy an important place. They are of direct importance as a source of forest products and of indirect importance as a habitat for wildlife, as a feature of the tourist trade, and in relation to water supplies. What is needed is an awareness of the public that when uncontrolled fires sweep through forest stands, damage is done to the community and Territory of which they are a part. What harms a country also harms its citizens.

Interior Alaska simply does not have "timber to burn"! Following a severe fire a minimum of 100 years and an average period of about 160 years must elapse before timber suitable for sawlogs again develops. It is doubtful if the Territory can wait that long! Occasionally, uncontrolled fires are condoned because they burn in young timber not of commercial size or because they burn in areas supporting growth that even the most optimistic forester would admit had no present or future commercial prospect. Two obvious facts may be pointed out in this connection. First, young trees are always small and all large trees were once young. Second, fires show no respect for values; seldom, if ever, does an extensive fire burn solely in "scrub" growth. Some potentially valuable timber is destroyed in every extensive burn.

The economic importance of wildlife, another of Alaska's great renewable resources, has been mentioned previously. It seems apparent that the widespread burning that has occurred during the past half-century or more has not resulted in a land teeming with fur-bearers and big game. It may well be doubted that more burning will produce such a result in the future.

The potential of the tourist business can scarcely be judged at this time but many thoughtful observers are of the opinion that it may well become one of Interior Alaska's most important sources of income. Here, again, unburned landscapes with their associated values are an asset and extensive burns are a liability. The nuisance of forest fires often extends far beyond the immediate limits of the area burned. Smoke, spreading over wide areas, is at best a source of annoyance and at worst a hazard to air travel and human life.

The destiny of Alaska can be achieved only if her resources are wisely used. Widespread destruction of forest and other vegetation by fire, with all its train of harmful effects, cannot be judged wise use. The citizens of the Territory have a serious responsibility for good stewardship if the future State of Alaska is truly to become "The Great Land".

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